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CASE REPORT

TREATMENT OF LATERAL KNEE PAIN BY ADDRESSING TIBIOFIBULAR HYPOMOBILITY IN A RECREATIONAL RUNNER

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ABSTRACT

Background. Altered joint arthrokinematics can affect structures distal and proximal to the site of dysfunction. Hypomobility of the proximal tibiofibular joint may limit ankle dorsiflexion and indirectly alter stresses about the knee.

Objectives. To examine the effect of addressing hypomobility of the proximal tibiofibular joint in an individual with lateral knee pain.

Case Description. A 24 year old female recreational runner presented with a three month history of right lateral knee pain. Limited right ankle dorsiflexion was noted and determined to be related to decreased mobility of the proximal tibiofibular joint, as well as, the talocrural and distal tibiofibular joints. Functional movement deficits were noted during the squat test and step down test. Treatment was performed three times over the course of two weeks which included proximal tibiofibular joint manipulation and an exercise program consisting of hip strengthening, balance, and gastrocnemius/soleus muscle complex stretching.

Outcomes. Immediately following intervention, improvements were noted for ankle dorsiflexion, squat test, and step down test. One week following the initial intervention the patient reported she was able to run pain free.

Discussion. Addressing impairments distant to the site of dysfunction, such as the proximal tibiofibular joint, may be indicated in individuals with lateral knee pain.

Key Words: ankle sprain, arthrokinematics, manipulation

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INTRODUCTION

The knee joint is the most commonly injured joint for runners and typical injuries include patellofemoral pain, iliotibial band syndrome, meniscus lesions, and patellar tendinopathy.[1] Knee pain about the lateral aspect of the knee is less commonly described and primarily thought to be related to iliotibial band syndrome[2] or a lateral meniscus lesion.[3] In the absence of these two conditions, other less common presentations could be lateral plica, fabella syndrome, biceps tendinosis, or popliteus tendinosis. A thorough examination of the local structures as well as distant sites may be helpful in the differential diagnosis of lateral knee pain.

An adjacent structure which may contribute to lateral knee pain is the proximal tibiofibular joint.[4-6] Previous authors[5, 6] have suggested that hypermobility of the proximal tibiofibular joint may be a source of lateral knee pain. During ankle dorsiflexion, torsional stress is placed through the proximal tibiofibular joint, via external rotation and anterior glide of the fibula.[6] Decreased mobility of the proximal tibiofibular joint may subsequently limit ankle dorsiflexion range of motion (ROM). Ankle dorsiflexion restrictions have been previously associated with anterior knee pain[7, 8] and are thought to be due to gastrocnemius/soleus tightness or talocrural joint hypomobility. No study has discussed the potential for hypomobility of the proximal tibiofibular joint and the contribution to lower extremity dysfunction. The purpose of this case report was to examine the effect of addressing hypomobility of the proximal tibiofibular joint in an individual with lateral knee pain.

CASE DESCRIPTION

The patient was a 24 year old recreational runner and reported an onset of right knee pain three months prior to initial examination. At that time she had been running 3-4 miles, 5-6 times a week, for the previous six months. After the onset of knee pain she reduced both distance and frequency to 2-3 miles, 2-3 times per week. She recalled no specific trauma or incident that precipitated the pain and reported symptoms only occurred during running and not other activities such as prolonged sitting or stair climbing. Although she was not experiencing pain (0/10) at rest, she rated her worst pain during running as 5/10. She described pain on the lateral aspect of knee which extended into the region of the proximal tibiofibular joint.

Her past medical history included a right lateral ankle sprain, which occurred six years previous. The patient did not seek medical consultation for this injury. She indicated that she had difficulty with walking for 2 to 3 days following the injury and severe ecchymosis resolved within one month. Based on her recall of the injury, the injury was likely be a grade II ankle sprain.[9] This injury was not disclosed until assessment of ankle mobility during the physical examination. The rest of her medical and orthopedic history was unremarkable.

Previous intervention for lateral knee pain had included the use of a patellar tendon strap, based on physician initial recommendations, but provided minimal relief of symptoms. Prior to examination the patient completed the Activity Measure for Post-Acute Care (AM-PAC) outcomes measure and scored 76 out of a possible 81.53.[10] Clinical outcomes collected during the initial examination and follow up sessions are presented in Table 1. The initial examination consisted of observation of static posture, dynamic movement including balance, strength, range of motion (ROM), joint mobility, and special tests.

TABLE 1. Clinical Outcomes

	Initial Evaluation	Immediately post Rx	Visit 2 (1 week)	Visit 3 (2 weeks)
Visual Analog Scale				
Current/Best/Worst	0/0/5	N/A	0/0/0	0/0/0
Dorsiflexion (degree) (knee extended)				
Right	5	10	10	15
Left	15	15	15	15
Dorsiflexion (degree) (knee flexed 90°)				
Right	8	10	12	20
Left	15	15	15	15
Step Down Test				
Right	5/6	3/6	1/6	1/6
Left	1/6	1/6	1/6	1/6
AM-PAC Score	76.58	N/A	81.53	81.53
Right = involved				

Static Posture and Functional Movement

Static posture was assessed visually in standing, and the right knee was held in slightly more knee flexion than the left knee. Functional movement examination included the squat test,[11] single limb stance, and step down test.[12] All tests were performed using visual observation. The squat test[11] was used to qualitatively examine the movement pattern and functional ROM of the lower extremity. During the descent phase of the squat, the patient's involved (right) lower extremity demonstrated dynamic knee valgus, which has been defined as a combination of femoral adduction, knee abduction, and ankle eversion,[13] compared to the uninvolved (left) lower extremity. A left weight shift was also noted and squat depth was limited on the right side relative to the left. This limitation was thought to be associated with a decrease in right ankle dorsiflexion motion, as compared to the left, which occurred without report of associated ankle pain. After discussion of this impairment, the patient recalled a history of right ankle sprain which had occurred six years previous.

Next, single limb stance was performed with eyes open while standing on a stable surface. The patient was able to balance 10 seconds on the right and 30 seconds on the left before losing balance. The last functional test was the step down test[12] which provided a quantitative assessment of lower extremity functional movement. This test was scored using established criteria *(Table 2)*[12] with lower scores (0 or 1) indicating good quality of movement and higher scores (5 or 6) indicating poor quality of movement. The patient scored 5 points on right (involved) and 1 point on the left (uninvolved) side.

Strength, Range of Motion, and Joint Mobility

Examination of lower extremity strength, ROM, and joint mobility occurred with the patient lying on a treatment table. Manual muscle testing indicated weakness of the right hip abductors (4/5) and hip external rotators (4/5) with all other major muscle groups determined to have full strength (5/5) with no re-creation of pain. The patient's lower extremity ROM was within a functional range and equal bilaterally with the exception of limited right ankle dorsiflexion. Active ankle dorsiflexion was assessed with both the knee extended (right, 5 degrees; left 15 degrees) and flexed to 90 degrees (right, 8 degrees; left 15 degrees).

Mobility of the patella was assessed with the patient in supine with the knee in full extension and determined to be normal and equal bilaterally. To determine if limited right ankle dorsiflexion was due to contractile or non-contractile tissues, further assessment of joint mobility was performed at the talocrural joint as well as the distal and proximal tibiofibular joints. Talocrural joint mobility *(Figure 1)* was assessed with the patient in a supine position with the ankle over the edge of the treatment table.[14, 15] The therapist stabilized the tibia and fibula with one hand while the other hand was placed over the talus. The webspace of the movement hand made contact with the neck of the talus while the fingers and thumb grasped the medial and lateral talus. Next, an anterior to posterior directed force was applied to determine the excursion and end feel of talar glide in the ankle mortise. The right talocrural joint was noted to be hypomobile with posterior glide of the talus on the tibia/fibula relative to the left.

Joint mobility of the proximal tibiofibular joint *(Figure 2)* was assessed with the patient in a hook-lying position.[15] The proximal tibia was stabilized with one hand while the thumb and index finger grasped the proximal fibular head. The fibular head was translated posterior to anterior in the plane of the articulation with the tibia. Compared to the left, the right proximal tibiofibular joint was determined to be hypomobile with limited anterior glide of the fibula on the tibia.

Next, mobility of the distal tibiofibular joint *(Figure 3)* was assessed with the patient in supine.[16] The therapist stabilized the distal tibia by making contact with the anterior aspect of the tibia with the thenar emi-

Table 2. Step Down Test (20 cm/8 in box) Scoring Criteria

Arm Strategy	1 point
If subject used an arm strategy in an attempt to recover balance	
Trunk Movement:	1 point
Trunk lean to side	
Pelvis Plane:	1 point
If pelvis rotated or elevated one side compared with the other	
Knee Position:	
Knee deviates medially and tibial tuberosity crossed an imaginary vertical line over either;	
the 2nd toe	1 point
medial border of the foot	2 points
Maintain steady unilateral stance:	
Stepped down on the non-tested side, or if test limb became unsteady (i.e. wavered from side to side on the tested side)	1 point

Movement Quality: Good: 0-1 points; Medium: 2-3 points; Poor: 4-6 points

Figure 1. *Mobility testing of the talocrural joint*

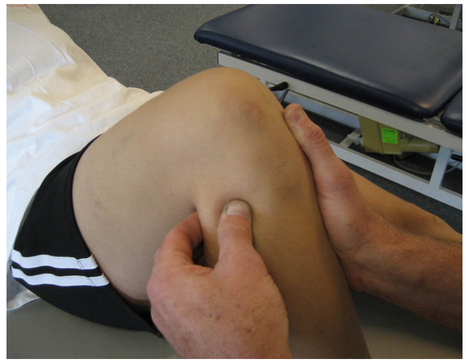

Figure 2. *Mobility testing of the proximal tibiofibular joint*

Figure 3. *Mobility testing of the distal tibiofibular joint*

nence and the posterior aspect of the tibia with a lumbrical grip. The other hand grasped the distal fibula with the anterior aspect in contact with the thenar eminence and the posterior aspect of the fibula in contact with the index finger. The distal fibula was translated in an anterior to posterior direction on the stable tibia and was determined to be hypomobile on the right relative to the left.

Based on the assessment of these three joints, the greatest restriction was determined to occur at the right proximal tibiofibular joint, which also reproduced familiar knee pain experienced by the patient. A second physical therapist, blinded to the initial examination findings, was asked to perform mobility assessment of the right proximal tibiofibular joint and pain provocation to confirm findings. The second physical therapist also noted hypomobility in the right proximal tibiofibular joint. Thus, clinical agreement with examination findings existed, but no statistical measures of intertester reliability were performed.

Palpation and Special Tests

The medial and lateral knee joint line and soft tissue structures including the patella tendon, medial and lateral retinacula, biceps tendon, and popliteus tendon were palpated without any complaint bilaterally. Palpable tenderness was reported on the right side along the distal aspect of the iliotibial band lateral to the patella and the fibular head.

Varus stress tests, McMurray's, and Apley's compression were all negative bilaterally. Isometric quadriceps contraction and patellar compression did not reproduce symptoms. Ober's Test and Thomas Test were equally limited bilaterally, per visual observation, but did not reproduce familiar pain. Noble compression test also did not reproduce pain with passive flexion and extension of the knee. Although these special tests are commonly performed in the assessment of lower extremity dysfunction, the sensitivity and specificity for iliotibial band syndrome has not been determined.

Evaluation and Differential Diagnosis

Based on evaluation of examination findings, the patellofemoral joint and iliotibial band were ruled out as sources of dysfunction. During the examination, the patient did not have pain with prolonged sitting, stairs (step down test), squatting, and palpation of the medial retinaculum. These findings indicated something other than patellofemoral joint pain was a cause of the dysfunction.[17] Iliotibial band syndrome was also ruled out as a cause due to the inability to provoke symptoms during Ober's or Thomas Tests.

Pertinent examination findings included limited right ankle dorsiflexion ROM, proximal tibiofibular joint hypomobility, provocation of familiar pain with proximal tibiofibular joint mobility testing, and abnormal lower extremity biomechanics during the squat and step down tests. Hypomobility of the patient's right tibiofibular joint was most likely the underlying cause of pain and dysfunction. At this point the decision was made to direct treatment to the patient's right proximal tibiofibular joint.

INTERVENTION

Initial intervention utilized a high velocity, end range, posterior to anterior thrust, applied to the proximal tibiofibular joint *(Figure 4)* in a manner consistent with previously published methods.[15,18] Briefly, the subject was in a supine position while the physical therapist aligned his index finger with the proximal fibular head and utilized the other hand to produce passive knee flexion and external rotation of the tibia. The associated soft tissue of the popliteal region was pulled in a lateral direction until the metacarpophalangeal joint was firmly stabilized behind the fibular head. The opposite hand grasped the anterior aspect of the ankle while the knee was passively flexed and the tibia was externally rotated. When the restrictive barrier was engaged, indicating the end of physiological motion, a high velocity, low amplitude thrust was applied through the tibia with the force directed towards the subject's heel toward the ipsilateral buttock.[18] An audible joint cavitation (pop) was felt and heard by the patient and heard by both physical therapists (treating and observing) that were in the room.

OUTCOME

Initial Visit

Following initial intervention, joint mobility of the proximal tibiofibular, distal tibiofibular, and talocrural joints of the involved extremity was re-assessed, using the same methods as previously described, and noted to have improved mobility, but still hypomobile relative to the uninvolved joints. Ankle dorsiflexion was reassessed using the same methods as the initial assessment. A 5 degree increase in ankle dorsiflexion occurred with the knee extended (right, 10 degrees; left 15 degrees) and a 2 degree increase with the knee flexed to 90 degrees (right, 10 degrees; left 15 degrees). Functional movements were also re-assessed with an improvement, per visual observation, in active ankle dorsiflexion during the squat test. The step down test was repeated and the score improved to three points which indicated improvement to medium quality of movement.

Additional treatment during the first clinical visit consisted of therapeutic exercises which included hip abduction in side-lying *(Figure 5)* and hip abduction/external rotation (clam shell) in crook lying *(Figure 6)*. Both exercises were performed for three sets of 30 repetitions each, to target hip abductor and external rotator muscles. The patient was instructed to maintain the trunk in neutral and isolate the hip abductor and external rotator muscles. These exercises were also incorporated into a home exercise program. The patient was also allowed to continue her current running program (2-3 miles, 2-3 times per week) with the stipulation that lateral knee pain did not increase during the activity.

Second Visit-One Week Following Initial Visit

One week following the initial visit, the patient reported improvement in symptoms and the ability to run without reproducing knee pain. The AM-PAC was repeated and a maximum score of 81.53 was obtained.[10] The step down test was performed and a score of one point was obtained bilaterally. Joint mobility of the proximal and distal tibiofibular joints and posterior glide of the talus were reassessed and determined to be improved compared to first visit but still hypomobile relative to the left side.

The patient's right proximal tibiofibular joint once again demonstrated the greatest amount of hypomobility, thus the treatment was directed at this joint. A proximal tibiofibular joint manipulation was performed using the

Figure 4. *Proximal tibiofibular joint manipulation*

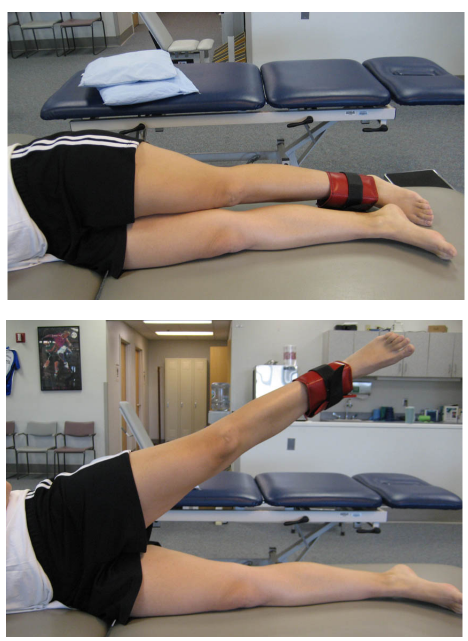

Figure 5. *Hip abduction in side-lying*

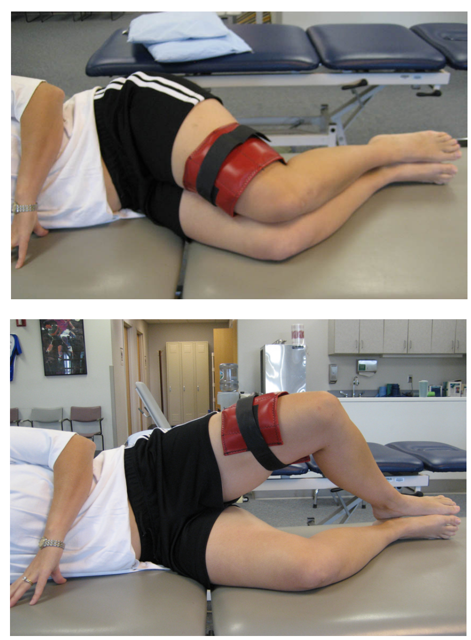

Figure 6. *Hip abduction and external rotation in crook-lying*

same technique as the first visit. Additionally, small amplitude, end of ROM (Grade IV), anterior to posterior joint mobilization[14] was performed at the talocrural joint with the subject lying in supine to improve posterior glide of the talus on the tibia/fibula. Therapeutic exercise program during the second clinical visit included the hip exercises performed during the initial visit as well as the addition of single limb stance exercises with repetitive rhythmic oscillations of the opposite limb performed with an elastic band attached to the opposite limb. This exercise was intended to increase strength and neuromuscular control of the lower extremity in a functional standing position. All exercises performed during the second clinical visit were also continued as part of the home exercise program.

Third Visit- Two Weeks Following Initial Visit

The patient returned for a third visit one week later and reported she was pain free, and still able to run without symptom exacerbation (0/10). The step down test was reassessed and the patient scored one bilaterally. Ankle ROM was also reassessed on the right side using the same methods as previously described. Compared to measurements during the initial examination, ankle dorsiflexion had improved 10 degrees with the knee extended (15 degrees) and 10 degrees with the knee flexed to 90 degrees (20 degrees). The AM-PAC score remained at a maximal obtainable score of 81.53.

Joint mobility of the proximal and distal tibiofibular joints and the talocrural joint was performed in a similar manner as previous examinations and was noted to be normal and equal bilaterally. Since the patient had no reports of pain, functional deficits, nor joint mobility restrictions the decision was made, with the consent of the patient, to discontinue physical therapy services and discharge her to her established home exercise program.

Follow-up

Ten months following discharge, the patient was contacted by phone for follow up evaluation of function. She reported that her knee and ankle had remained symptom free, and she was able to run 4-5 miles, 4-5 times per week. Another telephone follow up was conducted sixteen months following discharge, and the patient indicated she continued to remain symptom free and had increased running distance to 4-8 miles 4-5 times per week.

DISCUSSION

In this case report, restricted mobility of the joints associated with the tibia, fibula, and talus may have been a contributing factor to lateral knee pain.[7] Decreased ankle dorsiflexion ROM[7, 8] and altered mobility of the tibiofibular joints[4-6] have been shown to be associated with knee pain. It is unknown if limited ankle dorsiflexion was a precipitating, or compensatory mechanism, but stresses may have been increased about the knee joint during gait.[19]

A plausible explanation for proximal tibiofibular joint dysfunction may be indirectly related to the history of a previous ankle sprain.[5] Changes in the positional alignment of the talus, tibia, and fibula have been implicated in a subpopulation of individuals with a history of ankle sprain.[3,20-23] Two positional faults have been described to occur at either the talocrural joint[21] or the distal tibiofibular joint.[3,20,22,23] At the talocrural joint, the talus is thought to migrate anteriorly following lateral ankle sprains due to the disruption of the ligaments restraining anterior talus translation.[21] At the distal tibiofibular joint, a slight anterior displacement of the fibula relative to the tibia is thought to occur.[3,20,22,23] Based on the arthrokinematics associated with the tibiofibular joints, anterior translation of the distal fibula is associated with a concomitant posterior translation (external rotation) of the proximal fibula.[24] Clinically the positional faults are recognized as decreased posterior glide of the talus *(Figure 1)* or distal fibula *(Figure 3)* or decreased anterior glide of the proximal fibula *(Figure 2)*, all of which manifest as decreased ankle dorsiflexion ROM.[3, 20-23] If altered arthrokinematics and compensatory movement patterns are not appropriately addressed following injury, an opportunity exists for future local and distant joint pathology.[25-27] Although the ankle sprain reported by the patient had occurred approximately six years previously, only within the past year had her activity level increased to the point where this dysfunction may have become symptomatic. It is possible that her level of function prior to the initiation of her running program nine months previous may have not been enough to create symptomatic dysfunction. Repetitive stresses through the lower quarter associated with running may have provided enough stress to the joints creating a painful response.

Manual therapeutic interventions[14, 28-30] are reported clinically to offer the ability to restore normal joint arthrokinematics. By addressing hypomobility of the proximal tibiofibular joints, lower extremity arthrokinematics may be restored, ultimately altering stresses placed at the local joint. It is possible that this restoration of arthrokinematics may have contributed to the patient's decreased lateral knee pain symptoms. Due to the nature of the case report and the use of a multifaceted home exercise program, a cause and effect relationship can not be determined.

Results of this case report should be approached with caution due to the nature the single subject design and limited reliability and validity of examination methods. Examiner bias may have also been present during analysis of functional movements and joint mobility following intervention. Additional study is required to examine the contribution of the proximal tibiofibular joint in individuals with lateral knee pain and better develop examination and treatment for lateral knee pain.

SUMMARY

Consideration of the potential for ankle joint hypomobility contradicts common clinical thoughts associated with a history of lateral ankle sprain. Although the lateral ligaments of the ankle may have laxity associated with ligament disruption, recent evidence suggests that hypomobility of the adjacent talocrural and tibiofibular joints may contribute to chronic dysfunction.[20,21,31,32] Dysfunction may be asymptomatic unless tissues are stressed with activities such as running. This case presentation documents that proximal tibiofibular hypomobility may serve as a contributor to lateral knee pain. A thorough history and examination of surrounding structures will help identify underlying impairments which contribute to dysfunction. The treating clinician should be aware of specific biomechanical deficits that may contribute to lateral knee pain, as well as additional treatment options such as manual interventions for this type of condition.

REFERENCES

1. Taunton JE, Ryan MB, Clement DB, et al. A retrospective case-control analysis of 2002 running injuries. *Br J Sports Med.* 2002;36:95-101.
2. Fredericson M, Cookingham CL, Chaudhari AM, et al. Hip abductor weakness in distance runners with iliotibial band syndrome. *Clin J Sport Med.* 2000;10:169-175.
3. Eren OT, Kucukkaya M, Kabukcuoglu Y, Kuzgun U. The role of a posteriorly positioned fibula in ankle sprain. *Am J Sports Med.* 2003;31:995-998.
4. Ogden JA. Subluxation of the proximal tibiofibular joint. *Clin Orthop Relat Res.* 1974;101.
5. Radakovich M, Malone T. The superior tibiofibular joint: The forgotten joint. *J Orthop Sports Phys Ther.* 1982; 3:129-132.
6. Semonian RH, Denlinger PM, Duggan RJ. Proximal tibiofibular subluxation relationship to lateral knee pain: A review of proximal tibiofibular joint pathologies. *J Orthop Sports Phys Ther.* 1995;21:248-257.
7. Willems TM, Witvrouw E, Delbaere K, et al. Intrinsic risk factors for inversion ankle sprains in male subjects: A prospective study. *Am J Sports Med.* 2005;33:415-423.
8. Lun V, Meeuwisse WH, Stergiou P, Stefanyshyn D. Relation between running injury and static lower limb alignment in recreational runners. *Br J Sports Med.* 2004; 38:576-580.
9. Lynch SA, Renstrom PA. Treatment of acute lateral ankle ligament rupture in the athlete. Conservative versus surgical treatment. *Sports Med*. 1999;27:61-71.
10. Jette AM, Haley SM, Tao W, et al. Prospective evaluation of the AM-PAC-CAT in outpatient rehabilitation settings. *Phys Ther.* 2007;87:385-398.
11. Cliborne AV, Wainner RS, Rhon DI, et al. Clinical hip tests and a functional squat test in patients with knee osteoarthritis: Reliability, prevalence of positive test findings, and short-term response to hip mobilization. *J Orthop Sports Phys Ther*. 2004;34:676-685.
12. Piva SR, Fitzgerald K, Irrgang JJ, et al. Reliability of measures of impairments associated with patellofemoral pain syndrome. *BMC Musculoskelet Disord.* 2006;7:33.
13. Myer GD, Ford KR, Palumbo JP, Hewett TE. Neuromuscular training improves performance and lower-extremity biomechanics in female athletes. *J Strength Cond Res.* 2005;19:51-60.
14. Green T, Refshauge K, Crosbie J, Adams R. A randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. *Phys Ther.* 2001;81:984-994.
15. Whitman JM, Childs JD, Walker V. The use of manipulation in a patient with an ankle sprain injury not responding to conventional management: A case report. *Man Ther.* 2005;10:224-231.
16. Hengeveld E, Banks K. *Maitland's Peripheral Manipulation.* 4th ed. Edinburgh: Elsevier; 2005.
17. Thomee R, Augustsson J, Karlsson J. Patellofemoral pain syndrome: A review of current issues. *Sports Med.* 1999; 28:245-262.
18. Hartman L. *Handbook of Osteopathic Technique.* 3rd ed. Cheltenham, United Kingdom: Stanley Thornes Limited; 1997.

19. Piva SR, Goodnite EA, Childs JD. Strength around the hip and flexibility of soft tissues in individuals with and without patellofemoral pain syndrome. *J Ortho Sports Phys Ther.* 2005;35:793-801.

20. Hubbard TJ, Hertel J, Sherbondy P. Fibular position in individuals with self-reported chronic ankle instability. *J Orthop Sports Phys Ther.* 2006;36:3-9.

21. Denegar CR, Hertel J, Fonseca J. The effect of lateral ankle sprain on dorsiflexion range of motion, posterior talar glide, and joint laxity. *J Orthop Sports Phys Ther.* 2002; 32:166-173.

22. Scranton Jr PE, McDermott JE, Rogers JV. The relationship between chronic ankle instability and variations in mortise anatomy and impingement spurs. *Foot Ankle Int.* 2000;21:657-664.

23. Berkowitz MJ, Kim DH. Fibular position in relation to lateral ankle instability. *Foot Ankle Int.* 2004;25:318-321.

24. Ogden JA. The anatomy and function of the proximal tibiofibular joint. *Clin Orthop Relat Res.* 1974;101-103.

25. Comerford MJ, Mottram SL. Movement and stability dysfunction- contemporary developments. *Man Ther.* 2001;6:15-26.

26. Suter E, Herzog W, Conway PJ, Zhang YT. Reflex response associated with manipulative treatment of the thoracic spine. *J Neuromusculoskeletal Sys.* 1994;2:124-130.

27. Utting MR, Davies G, Newman JH. Is anterior knee pain a predisposing factor to patellofemoral osteoarthritis? *Knee.* 2005;12:362-365.

28. Dananberg HJ. Manipulation of the ankle as a method of treatment for ankle and foot pain. *J Am Podiatr Med Assoc.* 2004;94:395-399.

29. Collins N, Teys P, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Man Ther.* 2004;9:77-82.

30. Kavanagh J. Is there a positional fault at the inferior tibiofibular joint in patients with acute or chronic ankle sprains compared to normals? *Man Ther.* 1999;4:19-24.

31. Hubbard TJ, Hertel J. Anterior positional fault of the fibula after sub-acute lateral ankle sprains. *Man Ther.* 2008;13:63-67.